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(54) METHOD OF MANUFACTURING A DOUBLE SIDED FLEX CIRCUIT FOR A DISK DRIVE WHEREIN A FIRST SIDE LEAD PROVIDES AN ETCHING MASK FOR A SECOND SIDE LEAD

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See application file for complete search history.

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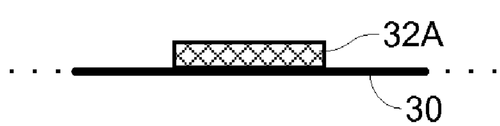
(57) **ABSTRACT**

A method of manufacturing a flex circuit is disclosed for a disk drive comprising a disk, a head actuated radially over the disk, and control circuitry. The flex circuit is for electrically coupling the head to the control circuitry and comprises a substrate. An electrical coating applied to a first side of the substrate is etched to form a first electrical lead. The first side of the substrate is irradiated with radiation such that the first electrical lead masks the radiation from passing through the substrate to prevent curing of a photoresist applied to the second side of the substrate to form an uncured photoresist and a cured photoresist on the second side of the substrate. The uncured photoresist is removed from the second side of the substrate to form a groove, and the groove is filled with electrically conductive material to form the second electrical lead.

6 Claims, 3 Drawing Sheets



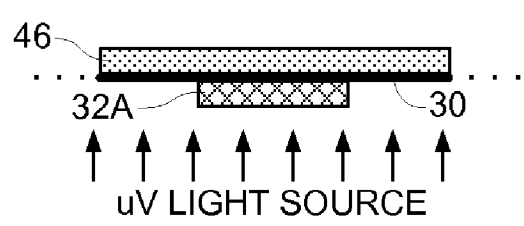


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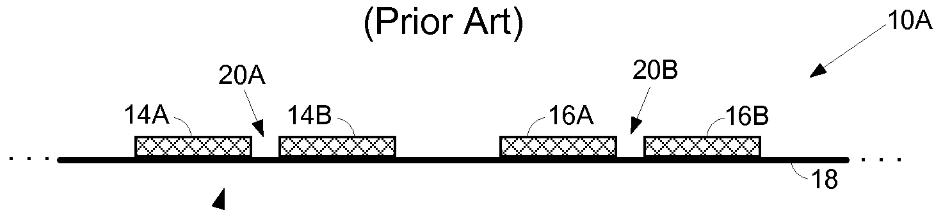
FIG. 1B
(Prior Art)



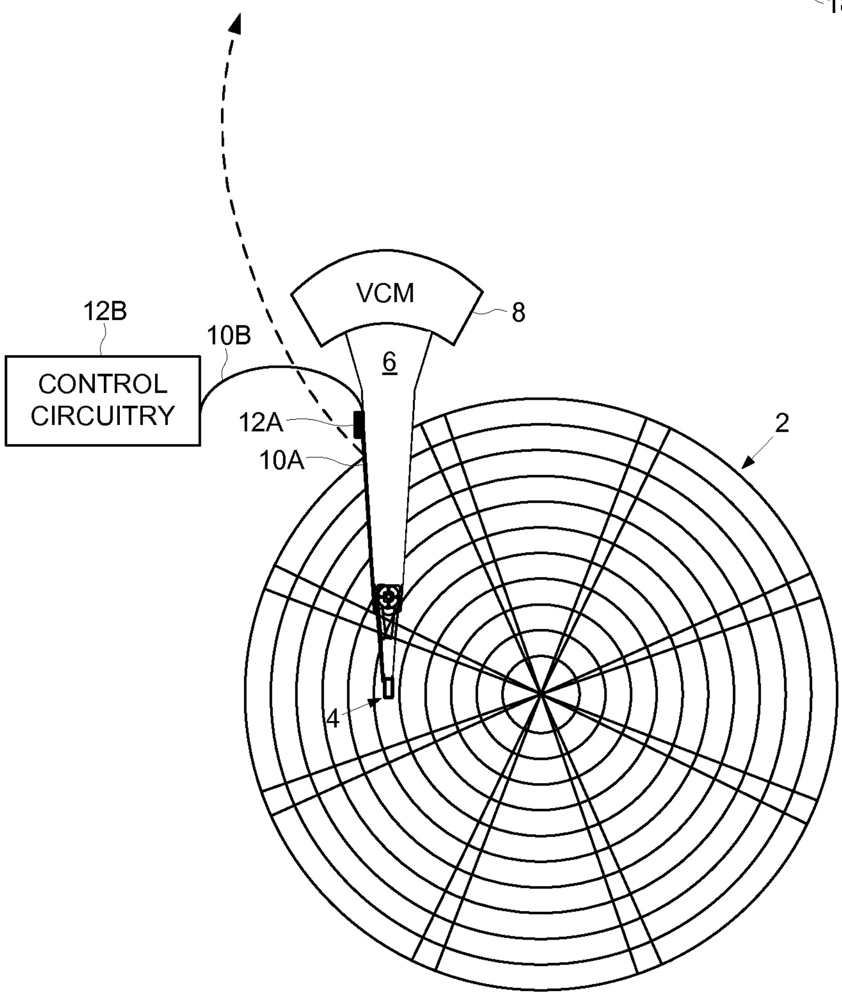


FIG. 1A
(Prior Art)

FIG. 2B

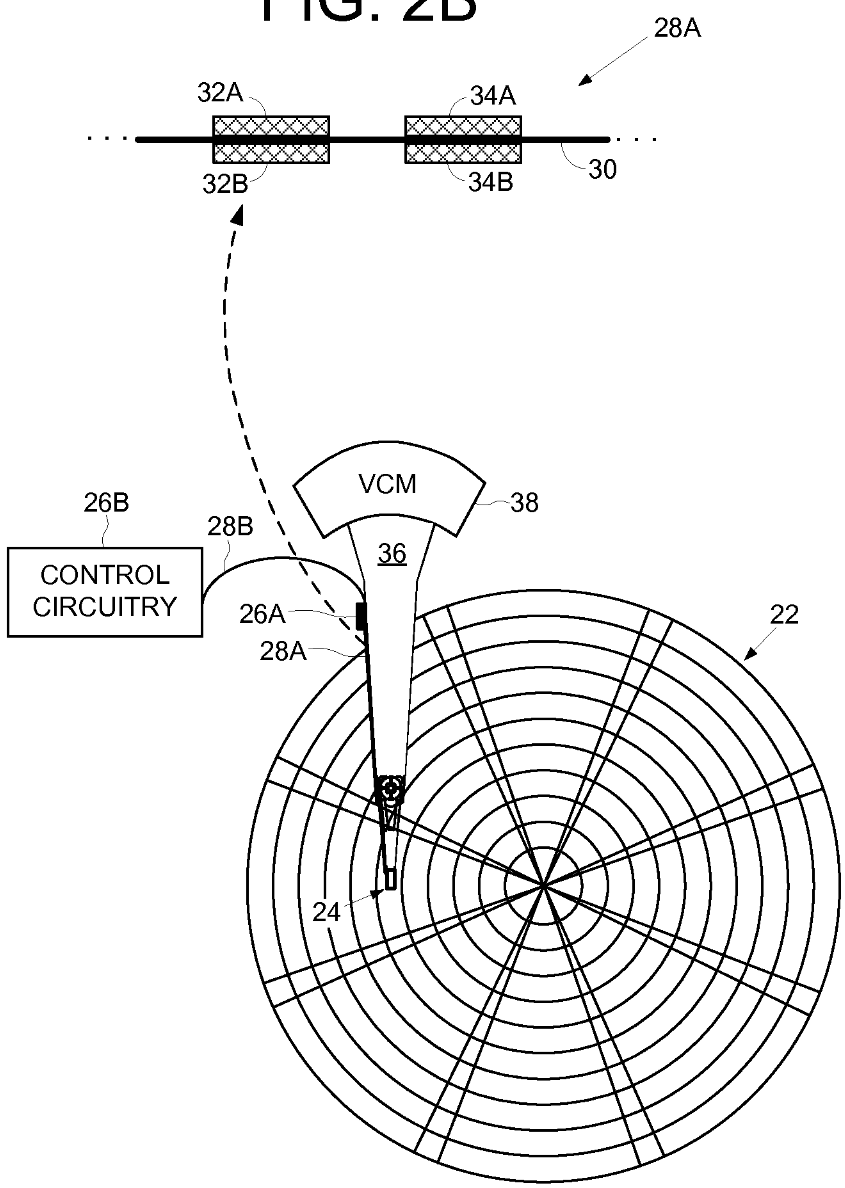

28A
32A
34A
32B
34B
30
VCM
38
36
26B
28B
CONTROL
CIRCUITRY
26A
28A
22
24

FIG. 2A

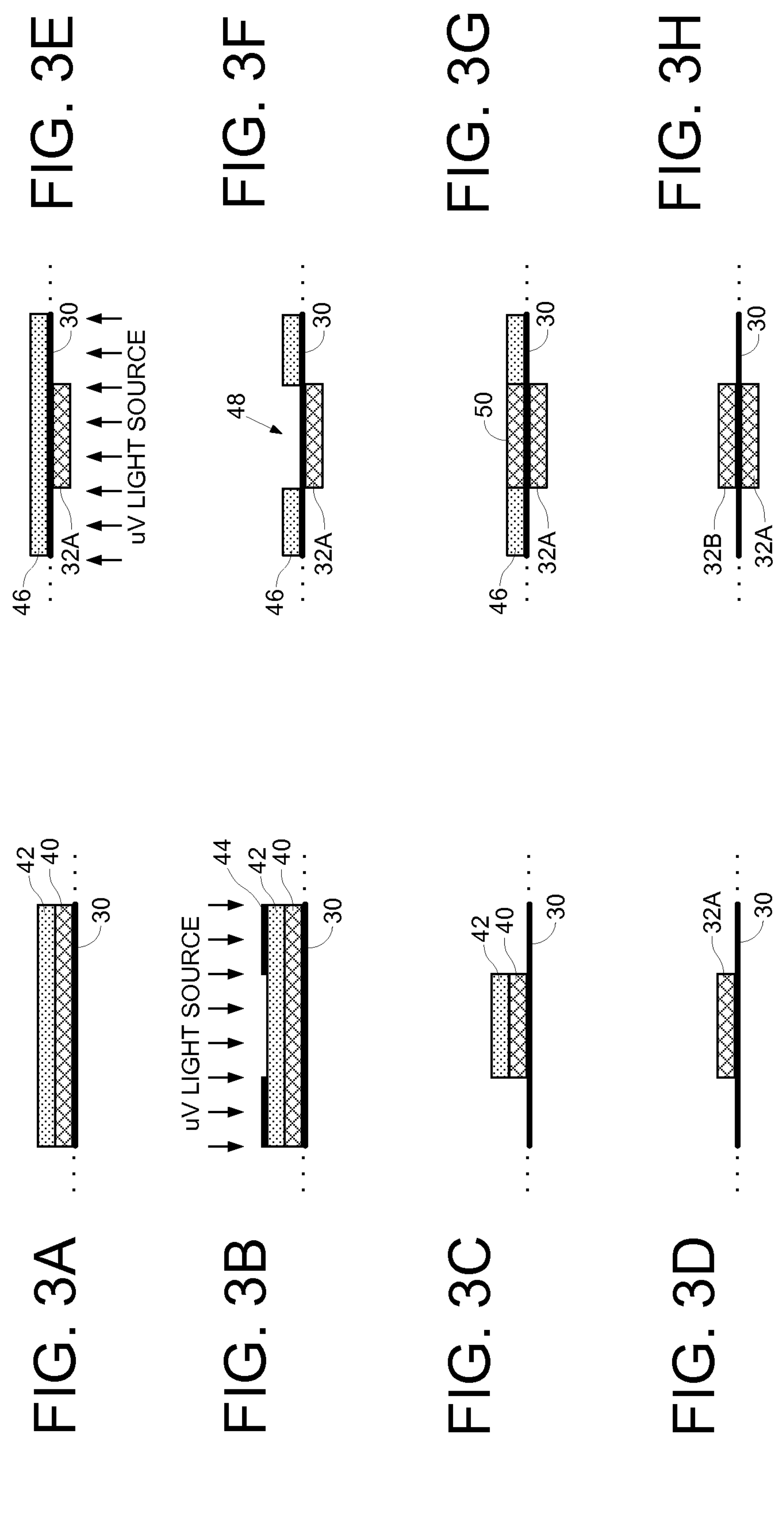


FIG. 3A
FIG. 3B
FIG. 3C
FIG. 3D
FIG. 3E
FIG. 3F
FIG. 3G
FIG. 3H

METHOD OF MANUFACTURING A DOUBLE SIDED FLEX CIRCUIT FOR A DISK DRIVE WHEREIN A FIRST SIDE LEAD PROVIDES AN ETCHING MASK FOR A SECOND SIDE LEAD

This application is a divisional of U.S. patent application Ser. No. 11/933,759 filed on Nov. 1, 2007 the specification of which is incorporated herein by reference.

BACKGROUND

1. Field

The present invention relates to disk drives for computer systems. In particular, the present invention relates to a disk drive comprising a double sided flex circuit wherein a first side lead provides an etching mask for a second side lead.

2. Description of the Related Art

FIG. **1**A shows a prior art disk drive comprising a disk **2** and a head **4** connected to a distal end of an actuator arm **6** which is rotated about a pivot by a voice coil motor (VCM) **8** to position the head **4** radially over the disk **2**. The head **4** may comprise an inductive write element (write coil) and a magnetoresistive read element (MR element) fabricated in very small dimensions using semiconductor fabrication techniques. A flex circuit **10** is typically employed to electrically couple the head **4** to control circuitry within the disk drive. In the example shown in FIG. **1**A, a first flex circuit **10**A couples the head **4** to a preamp **12**A mounted on the actuator arm **6**, and a second flex circuit **10**B couples the preamp **12**A to other control circuitry **12**B mounted on a printed circuit board, wherein the second flex circuit **10**B facilitates the movement of the actuator arm **6**. In other disk drives, the preamp **12**A may be integrated with control circuitry **12**B such that flex circuit **10**A couples the head **4** directly to the control circuitry **12**B mounted on the printed circuit board.

FIG. **1**B shows a magnified cross-sectional view of the flex circuit **10**A as comprising electrical leads for carrying differential signals, such as a differential write signal **14**A and **14**B and a differential read signal **16**A and **16**B for the head **4**. The electrical leads are supported by a substrate **18** which may comprise any suitable material, such as a polyimide. The electrical leads are typically formed using conventional etching techniques on one side of the substrate **18** such that the electrical leads for carrying the differential signal are separated by an air gap (e.g., air gap **20**A and **20**B).

As the data rate in disk drives increases into the microwave region, the transmission properties of the electrical leads for carrying the differential signals has become more significant. For example, it is desirable to reduce the impedance of the electrical leads in order to increase power efficiency as well as the signal-to-noise ratio (SNR) of the differential signal.

There is, therefore, a need in a disk drive to reduce the impedance of the electrical leads fabricated on a flex circuit in order to improve the power efficiency and SNR in transmitting differential signals along the electrical leads.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A shows a prior art disk drive comprising a head actuated over a disk and a flex circuit for coupling the head to control circuitry.

FIG. **1**B shows a prior art flex circuit comprising electrical leads for carrying differential signals fabricated on a single side of a substrate.

FIG. **2**A shows a disk drive according to an embodiment of the present invention comprising a head actuated over a disk and a flex circuit for coupling the head to control circuitry.

FIG. **2**B shows a flex circuit according to an embodiment of the present invention wherein the electrical leads for carrying differential signals are fabricated on opposite sides of a substrate, wherein a first electrical lead provides an etching mask for etching the second electrical lead.

FIGS. **3**A-**3**H show a method of manufacturing the flex circuit according to an embodiment of the present invention wherein a first electrical lead provides an etching mask for etching the second electrical lead.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

FIG. **2**A shows a disk drive according to an embodiment of the present invention including a disk **22**, a head **24** actuated radially over the disk **22**, control circuitry **26**A and **26**B, and a flex circuit **28**A for electrically coupling the head **24** to the control circuitry **26**A (a preamp in the example shown in FIG. **2**A). The flex circuit **28**A (FIG. **2**B) comprises a substrate **30**, a first electrical lead **32**A coupled to a first side of the substrate **30**, wherein the first electrical lead **32**A is operable to conduct a first signal of a differential signal, and a second electrical lead **32**B coupled to a second side of the substrate **30** opposite the first side, wherein the second electrical lead **32**B is operable to conduct a second signal of the differential signal. The first electrical lead **32**A provides an etching mask for etching the second electrical lead **32**B, and the first electrical lead **32**A is substantially aligned with the second electrical lead **32**B such that the substrate **30** forms a capacitive dielectric.

In the embodiment of FIG. **2**A, the head **24** is connected to a distal end of an actuator arm **36** which is rotated about a pivot by a voice coil motor **38** in order to actuate the head **24** radially over the disk **22**. A first flex circuit **28**A couples the head **24** to a preamp **26**A mounted on the actuator arm **36**, and a second flex circuit **28**B couples the preamp **26**A to other control circuitry **26**B mounted on a printed circuit board. As the actuator arm **36** rotates, the second flex circuit **28**B bends to facilitate the movement of the actuator arm **36**. In an alternative embodiment, the preamp **26**A is integrated with the other control circuitry **26**B such that flex circuit **28**A couples the head **24** directly to the control circuitry **26**B mounted on the printed circuit board.

The flex circuit **28**A may comprise electrical leads for carrying any suitable differential signal. In one embodiment, the head **24** comprises a magnetoresistive (MR) head comprising a write element having a first differential signal interface (e.g., **32**A and **32**B) and a read element having a second differential signal interface (e.g., **34**A and **34**B). As described above, it is desirable to reduce the impedance of the electrical leads carrying a differential signal in order to increase power efficiency as well as the signal-to-noise ratio (SNR) of the signals. The impedance can be reduced by increasing the capacitance between the electrical leads, and in the embodiment shown in FIG. **2**B, the impedance is reduced due to the increased capacitance of the substrate **30**. However, in order to take full advantage of the capacitive dielectric property of the substrate **30**, in one embodiment the first electrical lead (e.g., **32**A) is substantially aligned with the second electrical lead (e.g., **32**B).

FIGS. **3**A-**3**H show a method of manufacturing the flex circuit **28**A according to an embodiment of the present invention so that the electrical leads carrying a differential signal are substantially aligned. Referring to FIG. **3**A, an electrical coating **40** is applied to a first surface of a suitable substrate **30** (e.g., a polymide), wherein the electrical coating **40** may comprise any suitable material, such as a metal alloy comprising copper, beryllium copper, nickel, or compositions thereof. A suitable photoresist **42** (e.g., a suitable polymer) is applied over the electrical coating **40**, and a mask **44** is placed over the photoresist **42** (FIG. **3**B). A suitable radiation source (e.g., ultraviolet light or visible light) is directed at the first surface so as to cure the photoresist **42** not covered by the mask **44**. Referring to FIG. **3**C, the uncured photo resist **42** and underlying electrical coating **40** are removed (etched) using a suitable etchant solution, such as acid ferric chloride. The cured photoresist **42** shown in FIG. **3**C is then removed (FIG. **3**D) using a suitable solution, such as an organic solvent (e.g., methylene chloride), leaving the first electrical lead **32**A shown in FIG. **2**B.

During the step of etching the electrical coating **40** applied to the first side of the substrate **30** to form the first electrical lead **32**A as described above with reference to FIGS. **3**A-**3**D the mask **44** may be inverted if a positive photoresist **42** is employed. In this embodiment, the masked part of the photoresist **42** is cured when developed and the unmasked (and uncured) photoresist **42** is removed together with the underlying electrical coating **40** as shown in FIG. **3**C.

Continuing now with FIG. **3**E, the substrate **30** is flipped over so that the second side is facing up, and a photoresist **46** is applied to the second side. The first side of the substrate **30** is then irradiated as shown in FIG. **3**E such that the first electrical lead **32**A masks the radiation from passing through the substrate **30** to prevent curing of the photoresist **46** applied to the second side of the substrate **30**, thereby forming an uncured photoresist and a cured photoresist on the second side of the substrate. In this embodiment, the substrate **30** is sufficiently transparent to pass the radiation, whereas the first lead **32**A masks the radiation. Referring to FIG. **3**F, the uncured photoresist **46** is removed from the second side of the substrate **30** to form a groove **48**. Referring to FIG. **3**G, the groove **48** is filled with electrically conductive material **50** using any suitable technique, such as a suitable deposition process (e.g., a liquid bath plating process or sputtering process). The cured photoresist **46** shown in FIG. **3**G is then removed as shown in FIG. **3**H, thereby forming the second electrical lead **32**B shown in FIG. **2**B.

As seen in FIG. **3**H, the first electrical lead **32**A is substantially aligned with the second electrical lead **32**B such that the substrate **30** forms a capacitive dielectric. In one embodiment, the capacitive dielectric of the substrate **30** increases the capacitance of the electrical leads **32**A and **32**B as compared to the air dielectric shown in the prior art of FIG. **1**B. Increasing the capacitance reduces the impedance of the electrical leads in order to increase power efficiency as well as the signal-to-noise ratio (SNR) of the differential signals.

What is claimed is:

1. A method of manufacturing a flex circuit for a disk drive, the disk drive comprising a disk, a head actuated radially over the disk, and control circuitry, wherein the flex circuit is for electrically coupling the head to the control circuitry and comprises a substrate, the method comprising:

etching an electrical coating applied to a first side of the substrate to form a first electrical lead;

irradiating the first side of the substrate with radiation such that the first electrical lead masks the radiation from passing through the substrate to prevent curing of a photoresist applied to a second side of the substrate, wherein the photoresist is formed into an uncured photoresist and a cured photoresist on the second side of the substrate;

removing the uncured photoresist from the second side of the substrate to form a groove; and

filling the groove with electrically conductive material to form a second electrical lead.

2. The method as recited in claim **1**, wherein the first electrical lead is substantially aligned with the second electrical lead such that the substrate forms a capacitive dielectric.

3. The method as recited in claim **1**, wherein the substrate comprises a polyimide.

4. The method as recited in claim **3**, wherein the polyimide is sufficiently transparent to pass the radiation.

5. The method as recited in claim **4**, wherein the radiation comprises ultraviolet light.

6. The method as recited in claim **4**, wherein the radiation comprises visible light.

* * * * *